INTERNET DOCUMENT INFORMATION FORM

A . Report Title: Hopper Dredge Mooring

B. DATE Report Downloaded From the Internet: 07/06/99

C. Report's Point of Contact: (Name, Organization, Address, Office Symbol, & Ph #):
Dredging Operations Technical Support
Attn: Dr. Engler (601) 634-3624
3909 Halls Ferry Road
Vicksburg, MS 39180-6133

D. Currently Applicable Classification Level: Unclassified

E. Distribution Statement A: Approved for Public Release

F. The foregoing information was compiled and provided by:
DTIC-OCA, Initials: __VM__ **Preparation Date 07/06/99**

The foregoing information should exactly correspond to the Title, Report Number, and the Date on the accompanying report document. If there are mismatches, or other questions, contact the above OCA Representative for resolution.

DRP-3-02
January 1990

Dredging Research
Technical Notes

Hopper Dredge Mooring

Purpose

This Technical Note presents the results of an investigation of hopper dredge mooring design.

Background

Accurate prediction of forces a buoy transmits and a mooring must withstand is critical to design of a single point mooring (SPM) system. As part of an effort under the Dredging Research Program to assess the feasibility of a single point mooring buoy for hopper dredge direct pumpout, the Chesapeake Division of the Naval Facilities Engineering Command (NAVFAC) calculated the mooring loads generated by the US Army Corps of Engineers large class hopper dredge *Wheeler* under a variety of wind, current, and wave conditions.

Additional Information

For additional information, contact the author, Mr. Thomas Chisholm, (601) 634-3099, or the manager of the Dredging Research Program, Mr. E. Clark NcNair, Jr., (601) 634-2070.

Mooring Systems Requirements

The Naval Facilities Engineering Command (NAVFAC) proposed two mooring designs: the single point mooring (SPM) and the fore-and-aft mooring (FAM). These designs are shown in Figures 1 and 2. The advantage of the SPM is that it allows the dredge to weathervane around the mooring and align itself to minimize mooring

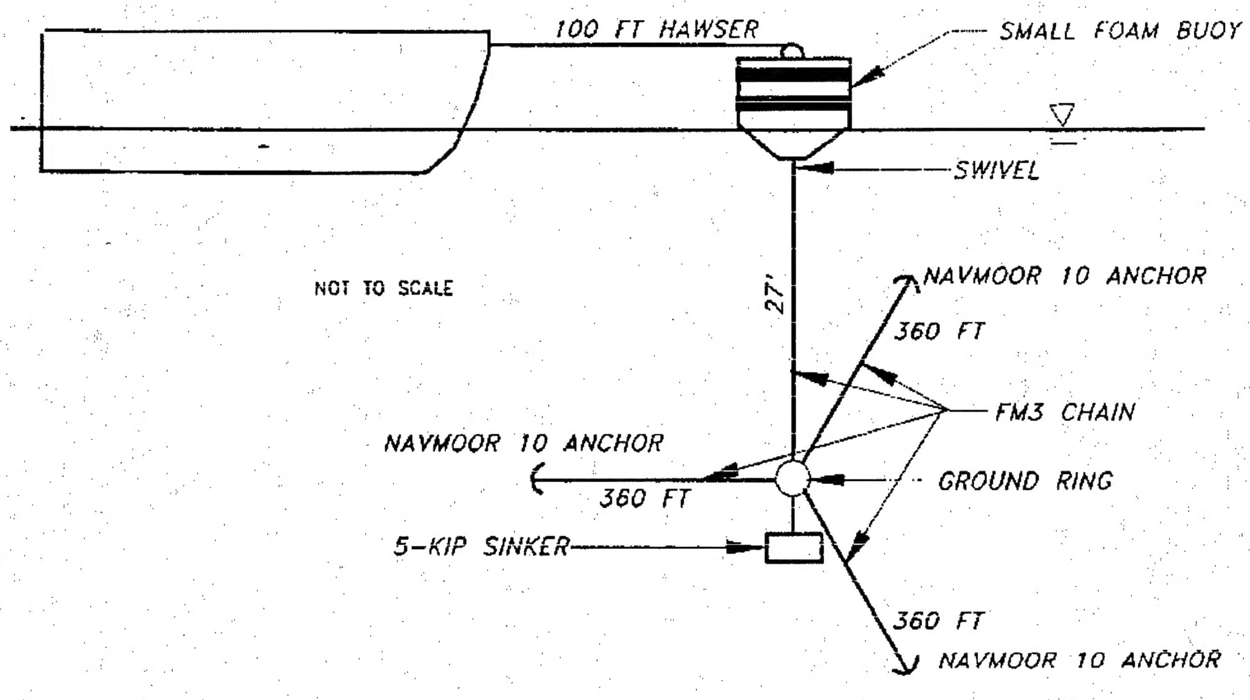


Figure 1. Single-Point Mooring (SPM) configuration

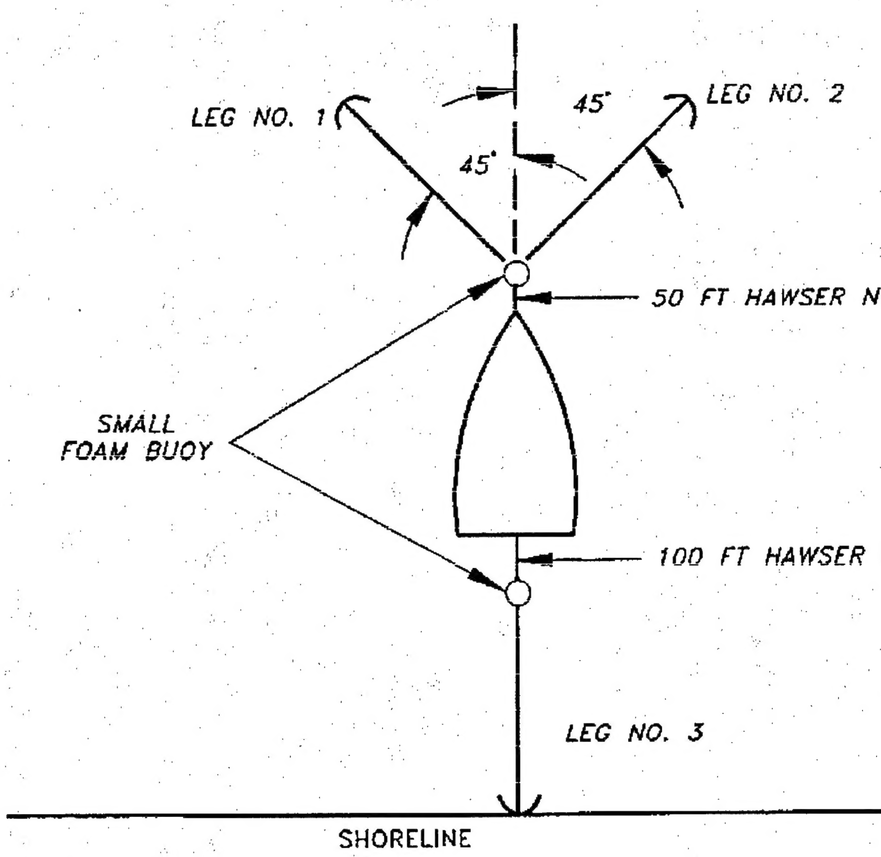


Figure 2. Fore and Aft Mooring (FAM) system

forces. The FAM holds the vessel in a fixed orientation, which is useful in a constricted area. If single point mooring were used as a monobuoy for direct pumpout (DPO) hopper dredges, three chains rising to the buoy would be required with a flexible hose in the center to carry slurry from the surface to a submerged pipeline. The mooring configuration shown in Figure 1 is similar enough to the SPM design for mooring force analysis purposes.

Both moorings analyzed by NAVFAC are made of standard Navy components. NAVMOOR-10 high efficiency anchors weigh 12,500 lb each. They have an ultimate holding capacity of 270,000 lb and a working holding capacity of 135,000 lb. The NAVMOOR-10 requires 8.5 ft of sand for full anchor penetration. Geotechnical investigation should be performed before mooring installation to determine sediment depth and type. NAVFAC specified 2-in.-diameter (Grade 3) US Navy FM3 mooring chain, which has a breaking strength of 454,000 lb and a working load capacity of 227,000 lb. The wet and dry unit weights of FM3 chain are 34 and 37 lb/ft, respectively.

NAVFAC performed its calculations assuming that the *Wheeler* (chosen for calculations because it is the largest Corps dredge and will provide an upper limit on mooring forces) would connect to the mooring using its own hawser, which is 2-in.-diameter braided polypropylene (Table 1). Most SPM's currently in use have a hawser permanently attached; the ship's hawser is not used. A nylon hawser instead of the polypropylene braided hawser would have better impact loading characteristics due to its increased elasticity.

Mooring Loads

The static forces due to wind and current were calculated for comparison with the dynamic cases. Results for the SPM and FAM are presented in Tables 2 and 3, respectively. Static forces are much lower than dynamic forces. FAM forces are higher than SPM forces. The listed FAM forces include 10,000 lb of pretensioning.

For dynamic cases, wind, waves, current, mooring forces, inertia, potential damping, and viscous damping were treated using computer models. SPM and FAM results are summarized in Tables 4 and 5, respectively.

For the SPM, surge, sway, and yaw motions were considered. Permutations of seas between 0 and 10 ft, winds of 30 and 40 knots, current orientation, and vessel draft were modeled. Computer model simulation was done using two different orientations between wind, waves, and currents: typical and severe environments, as shown in Figure 3. The position relative to the environment shown in Figure 3 is the initial position. The ship will swing and align itself to minimize forces. The severe environment has the wind perpendicular to the waves. This situation occurs less frequently than the typical environment which has the wind and waves 30 deg apart. The current was 0.6 knot in all cases. Computer runs simulated 2,200 sec (36-2/3 min) of real time, but the first 400 sec (6-2/3 min) were considered transient and are not included in the results.

Table 1

Wheeler Hopper Dredge Hull Characteristics

Characteristic	Mean Light Draft	Loaded Draft
Overall length, ft	408	408
Waterline length, ft	384	384
Beam, ft	78	78
Draft, mean, ft	21.5	29.5
Displacement, long tons	9,846	19,059
Broadside wind area, sq ft	16,200	13,000
Longitudinal wind area, sq ft	7,500	6,900

Table 2

Single-Point Mooring (SPM) Static Load Summary

Wind Speed knots	Light Draft Peak Mooring Load kips	Loaded Draft Peak Mooring Load kips
10	4	6
20	8	13
30	18	17
40	32	30

Table 3

Fore and Aft Mooring (FAM) Static Load Summary

Wind Speed knots	Light Draft Peak Mooring Load kips	Loaded Draft Peak Mooring Load kips
10	16	14
20	37	30
30	72	58
40	121	96

Table 4

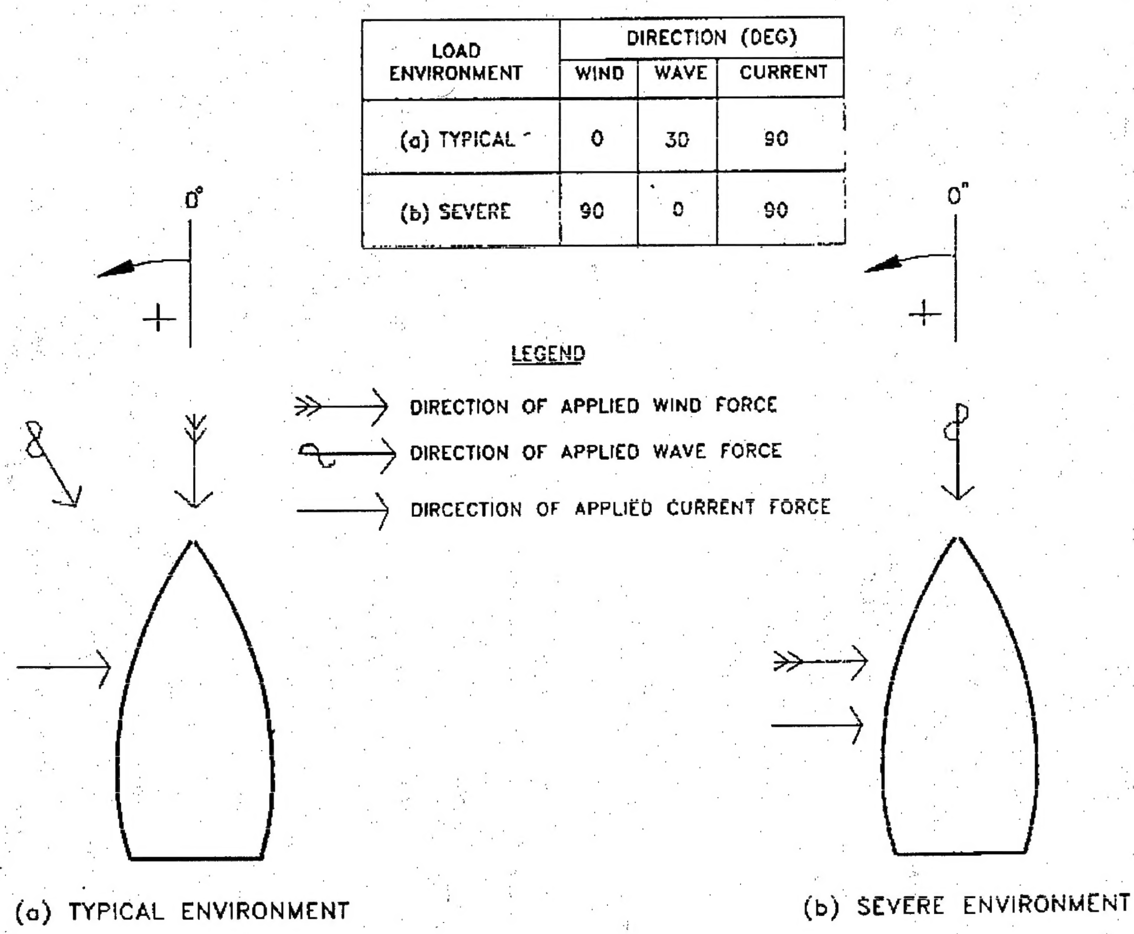
Single-Point Mooring (SPM) System Safety Factors

Wind Speed knots	Significant Wave Height ft	Peak Mooring Load kips	Safety Factor on Chain	Safety Factor on Anchor Drag	
		Light Draft, Typical Environment			
30	None	17	26.7	15.9	safe
40	None	28	16.2	9.6	
30	5.0	29	15.7	9.3	
40	5.0	46	9.9	5.9	
30	7.5	45	10.1	6.0	
40	7.5	103	4.4	2.6	
30	10.0	84	5.4	3.2	
40	10.0	178	2.6	1.5	unsafe
		Light Draft, Severe Environment			
30	5.0	58	7.8	4.7	safe
40	5.0	86	5.3	3.1	
30	7.5	130	3.5	2.1	
40	7.5	135	3.4	2.0	
30	10.0	292	1.6	0.9	unsafe
40	10.0	324	1.4	0.8	
		Loaded Draft, Typical Environment			
30	None	15	30.2	18.0	safe
40	None	25	18.2	10.8	
30	5.0	96	4.7	2.8	
40	5.0	119	3.8	2.3	
30	7.5	163	2.8	1.7	unsafe
40	7.5	158	2.9	1.7	
30	10.0	185	2.5	1.5	
40	10.0	262	1.7	1.0	
		Loaded Draft, Severe Environment			
30	5.0	171	2.7	1.6	unsafe
40	5.0	202	2.2	1.3	
30	7.5	294	1.5	0.9	
40	7.5	318	1.4	0.8	
30	10.0	321	1.4	0.8	
40	10.0	316	1.4	0.9	

Table 5

Fore and Aft Mooring (FAM) System Safety Factors

Wind Speed knots	Significant Wave Height ft	Peak Mooring Load kips	Safety Factor on Chain	Safety Factor on Anchor Drag	
		Light Draft, Typical Environment			
20	5.0	138	3.3	2.0	safe
25	5.0	177	2.6	1.5	unsafe
30	5.0	219	2.1	1.2	
20	7.5	276	1.6	1.0	
25	7.5	342	1.3	0.8	
30	7.5	601	0.8	0.4	



LOAD ENVIRONMENT	DIRECTION (DEG)		
	WIND	WAVE	CURRENT
(a) TYPICAL	0	30	90
(b) SEVERE	90	0	90

Figure 3. Simulated environmental orientation

Six FAM cases were modeled. All used a modification of the typical condition (Figure 3) in which the current and wind directions were interchanged. The current was 1 ft/sec. The vessel was in the light draft condition. All 6 deg of motion (surge, sway, heave, yaw, pitch, and roll) were analyzed. FAMs impose higher mooring forces than SPMs. Therefore, using FAMs on most exposed coasts will result in more weather downtime than SPMs.

In the light draft condition, the dredge causes lower forces than in the loaded draft condition. The severe environment, as implied, causes higher forces than the typical environment. At most locations environmental conditions will occasionally exceed the operational limits of the mooring. The anticipated lost time should be included in cost estimates.

This Technical Note describes the forces for one particular vessel using a mooring installation and gives an idea of the magnitude of the forces to anticipate for this class of mooring problem. The dynamic loads will vary with the impact load absorption ability of the mooring system. The loads should be less for a smaller vessel. Before a single point or other mooring is installed, additional detailed analysis of the particular system to be used should be performed. Selection of a mooring system requires consideration of factors other than mooring forces such as the dredge used and the site-specific physical environment.